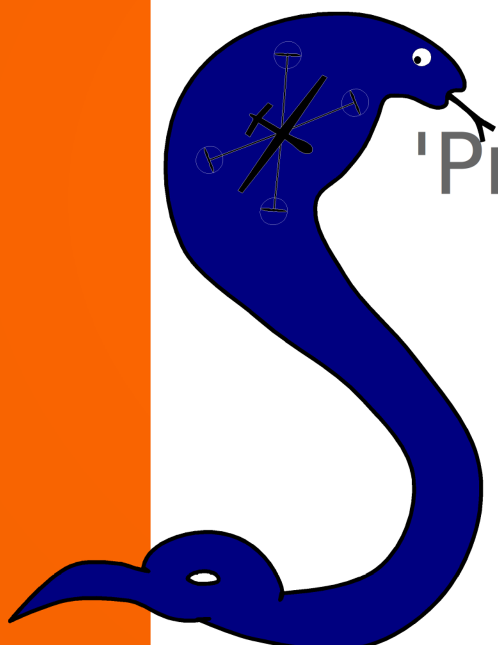

SSEDD

'Pro-Maker style' drones for science

J Wyngaard

Postdoctoral scholar

University of Southern California

Overview

- Drones in Earth Science Currently
  - Examples
  - Steady Style
- 'Pro-Maker Style' Drones for science
  - Solved problems
  - Unsolved problems
  - Some solutions - SSEDD
- Conclusions and Future Plans

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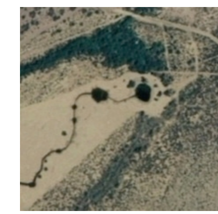
Drones in Earth Science:

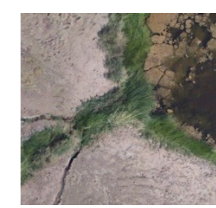
- Benefits
  - Scientific:
    - Lower environmental impact
    - Access
    - Temporal Resolution (repeatability)
    - Spatial Resolution
  - Practical:
    - Improved human saftey
    - Costs saving

LANDSAT 8 (30m)



NAIP 2010 (1m)

UAS 400ft(5cm)



UAS 250ft(2.5m)

USGS: Unmanned Aircraft Systems (UAS) Activities in Earth Sciences - June 2015

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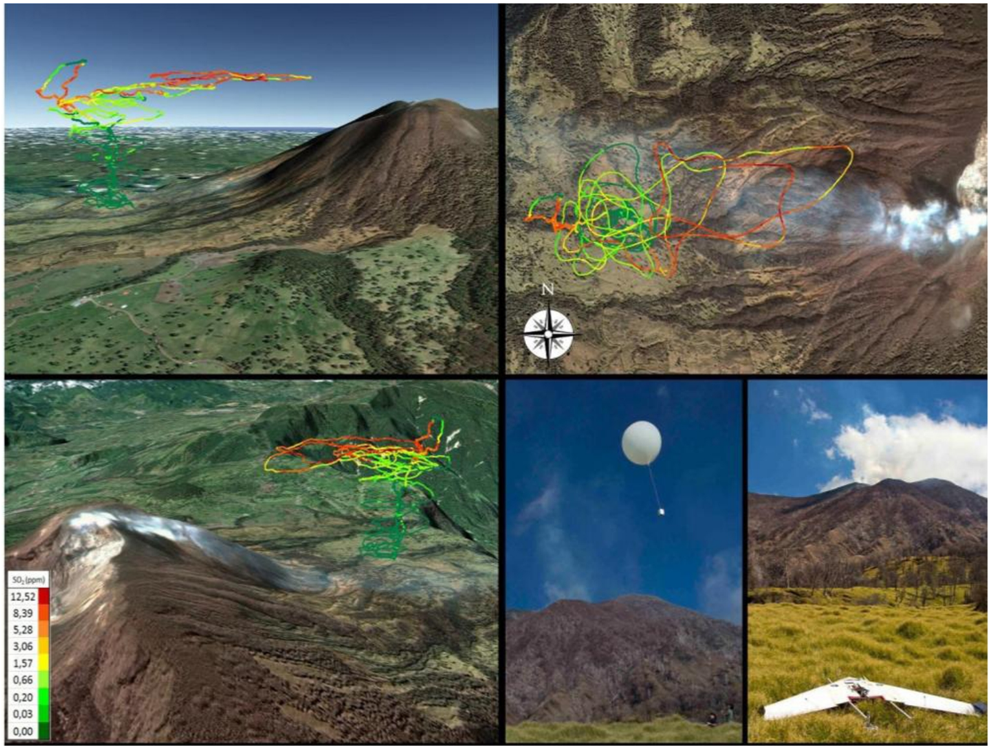
Volcanic Plumes

- Dr Diaz, NASA AIMES, University of Costa Rica
  - Real time monitoring of Volcano status
  - Validation of ASTER (Advanced Spaceborne Thermal Emission and Reflection) instrument on Terra spacecraft
- Dragon Eye (ex military)
  - 2.6kg
- Vector Wing 100
  - 8x5ft
  - 100kg payload



3D SO2 concentration plots- "Unmanned Aerial Mass Spectrometer Systems for In-Situ Volcanic Plume Analysis" Jorge Andres Diaz et al, AMSA 2015

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Polar Sciences

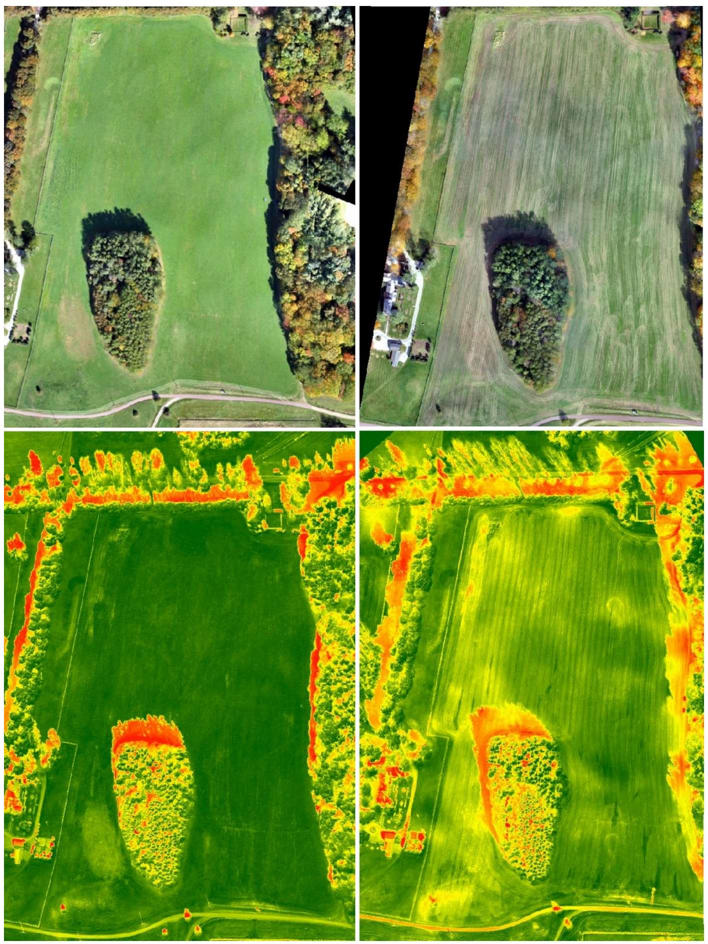
- Glacier mass monitoring
- Glacier Ablation zone monitoring
- Wild life population tracking
- Mapping

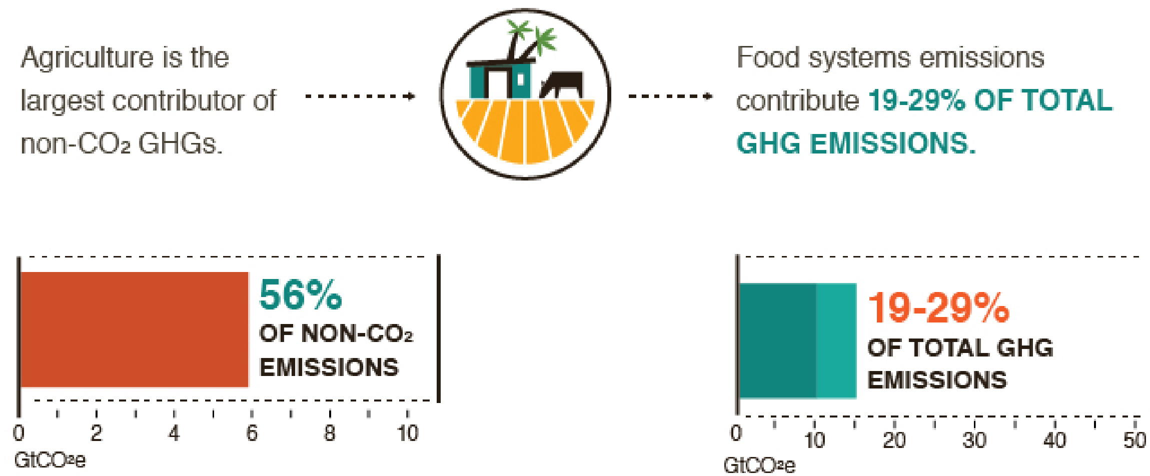
"But there I was, doing quick order-of-magnitude approximations in my head while our quad-copter lifted off into the air to single-handedly create a data management nightmare"

- Sean Barberi, University of Fairebanks Alaska

Agriculture

15/10/15 Pre Manure | 26/10/15 Post Manure





NDVI
University of Vermont, Spatial Analysis Lab, 2015

Agriculture

- Green House gas emmisions monitoring:
  - 20min/chamber measurement
  - 10 chambers
  - …

Lindsay Barbieri
University of Vermont

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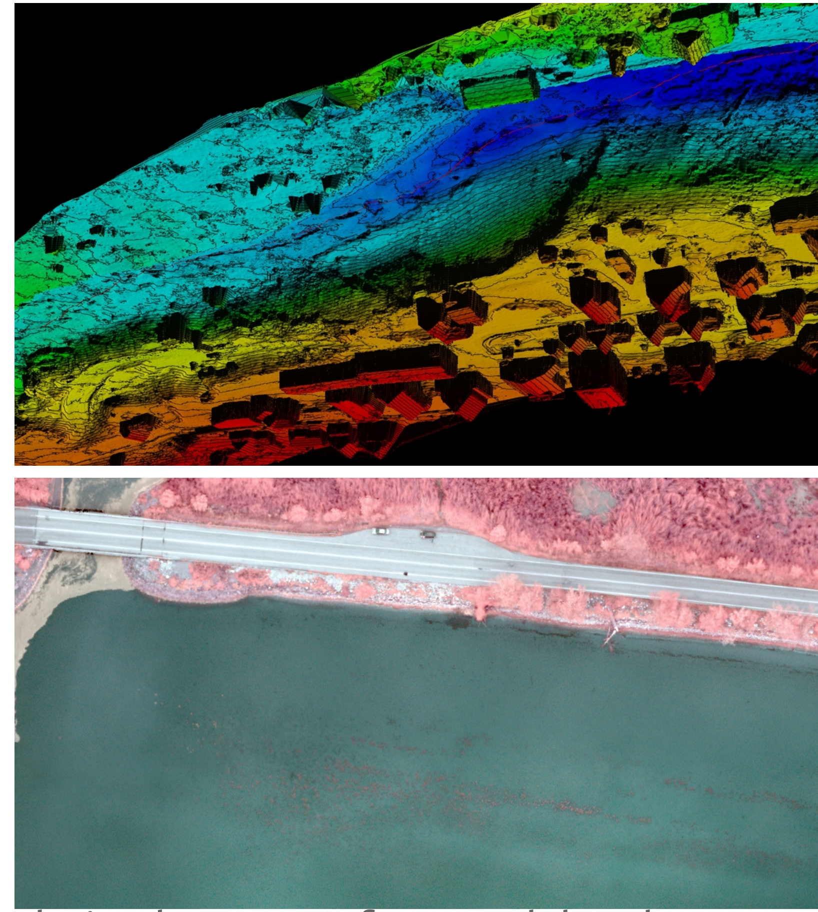
So Many More

- Feature extraction
  - Rapid disaster managment analysis
  - Wildfire emergency response
- Volumetric measurements
  - Geomorphic and Hydrologic change monitoring
- Color infrared
  - Algea bloom quantification



Top: UAS derived raster surface model and contour data shows substantial geomorphic change following a major flooding event.
Bottom: Color infrared UAS orthophoto mosaic of St. Albans Bay. 4cm resolution clearly reveals fine-scale aquatic vegetation - **University of Vermont, Spatial Analysis Lab**

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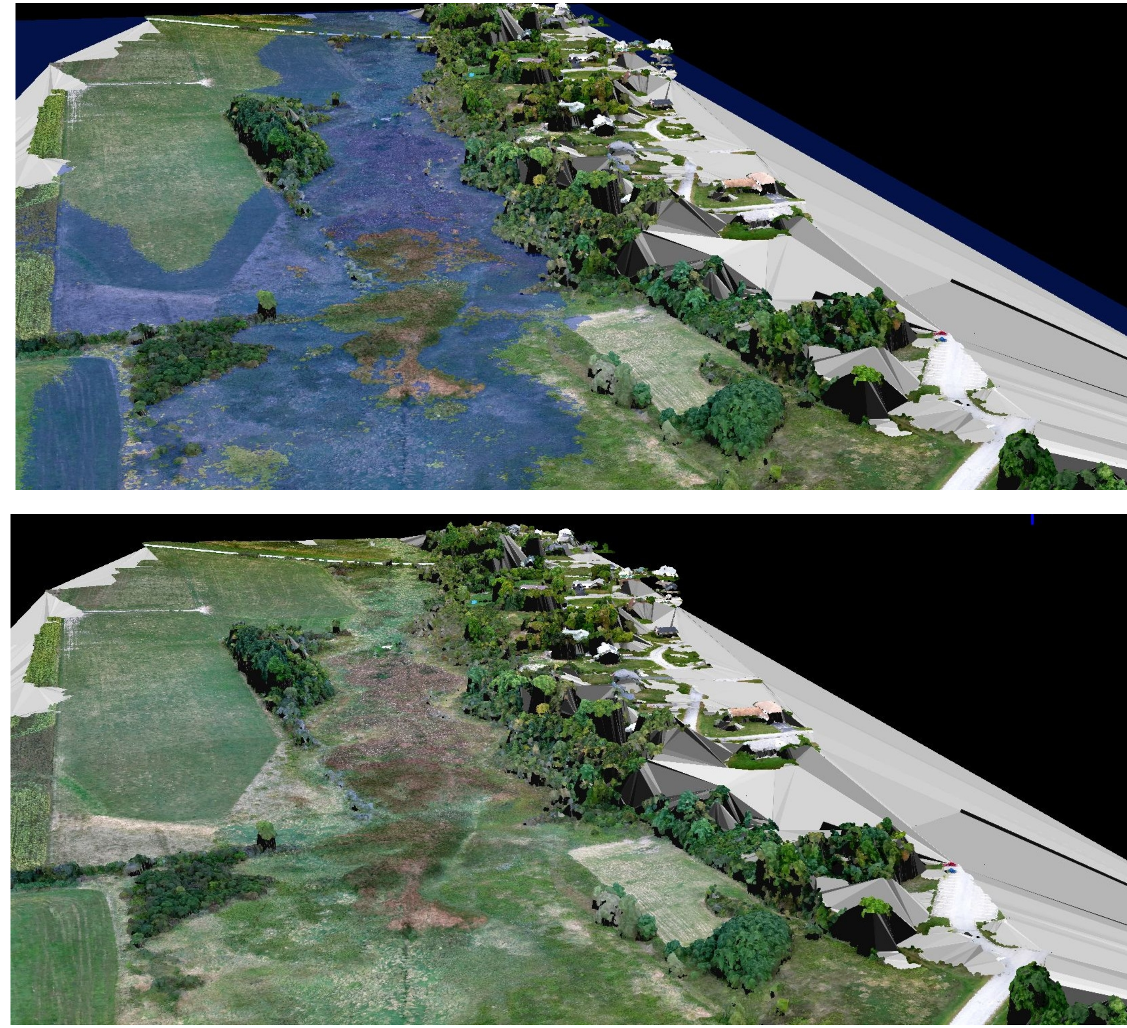
So Many More

- Elevation models
- Point cloud generation
- 3D modeling
  - Crevass/Cave mapping
  - Flood inundation modeling
  - Boundary layer atmospheric conditions capture



University of Vermont, Spatial Analysis Lab

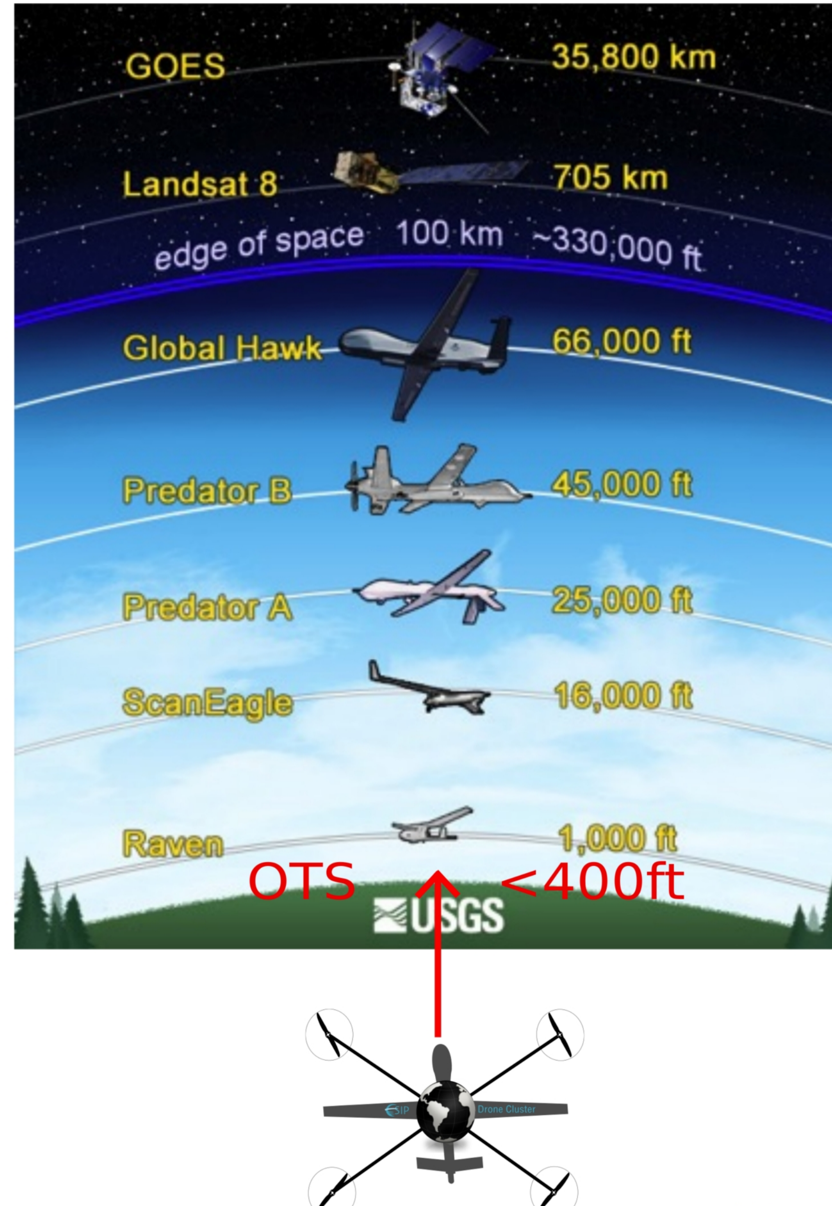
Drones in Earth Science: Steady Style

- Pros:
  - Big systems
    - Long flight times and distances
    - Large sophisticated sensors
    - Wide range of operating conditions
  - Robust Systems
  - Moderate re-use
- Cons:
  - Long development cycles
  - Equivalent very high costs
  - Limited flexibility

NASA GlobalHawk:
- 8,500-nautical-mile range
- 24-hour endurance
- >7000kg payload capacity
- ~$130M

Drones in Earth Science: Steady Style

- Falcon
  - ~3-5kg
  - ~$3000/hr
  - <100km
  - ~1.2kg payload
  - Pixhawk flight controller



'Pro-Maker Style' Drones for science

- "…a standard tool in an Earth Scientists toolbox." - USGS webinar, 2015* **(Think multimeter)**
- Off the shelf flight systems
- Low cost
- Rapidly evolving
- Highly adaptive
- Community based, grown, maintained
- Professional sensors
- Interoperable data
- Cloud/Container based analytics tools
- High degree of automated quality control * **(Think ERC checker)**

Solved problems

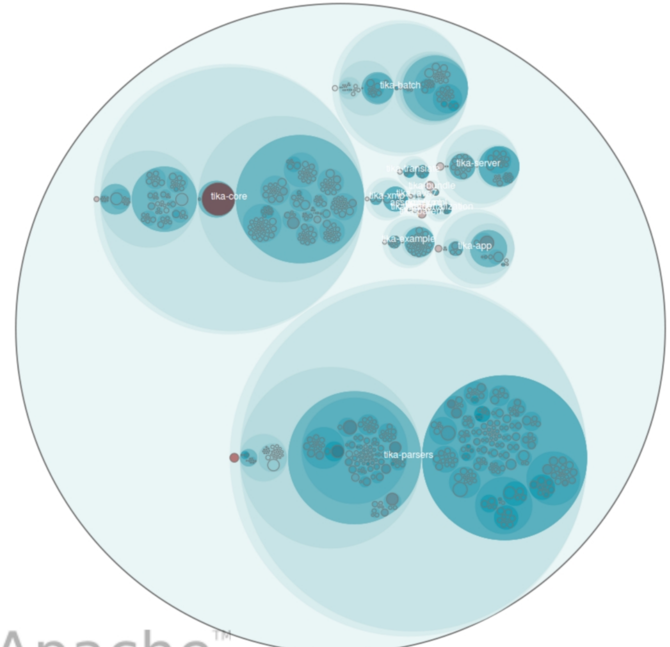
- Solved (and improving) problems – for these purposes at least
  - Open Autopilots
  - Open communication standards
  - Open mission planning
  - Open simulation framework to build customized flight control applications.
  - Developer APIs

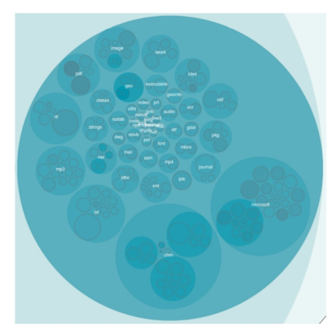
Dronecode

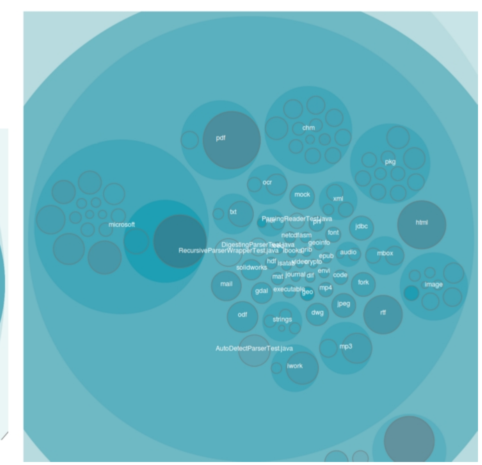
Unsolved problems – the 'Pro' bit

Data...

- Provenance
  - Metadata standards
    - Sensors, Aircraft
  - Geo-referenced data
  - DOIs
- Interoperability – formats...
  - Satellite, Ocean Gliders, sensor Webs, Computational modes
- Accessibility
  - DOIs
  - Searchable
  - Discoverable



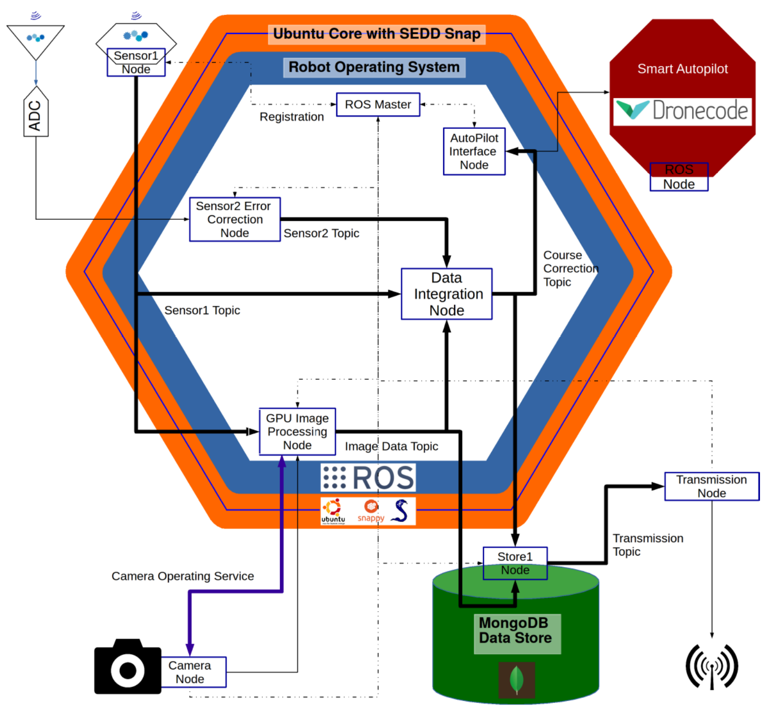




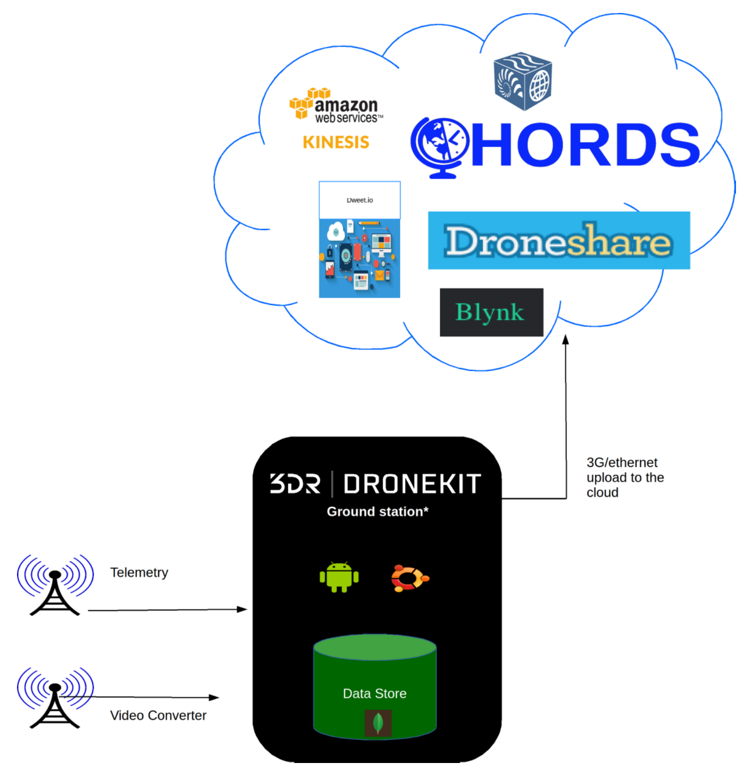
Unsolved problems – the 'Maker' bit

Science **S**tandardised **E**mbedded **D**ata infrastructure for **D**rones

IN-FLIGHT COMPUTE



GROUND STATION AND THE CLOUD



SSEDD

- Snappy
  - Multi-platform
    - Raspberry Pi, Beaglebone, Dragon board,… - list growing fast ?
  - Easy to install applications
    - GHG snap?
    - SFM snap?
    - DEM snap?
  - Full OS with std tools built in
  - Security built in

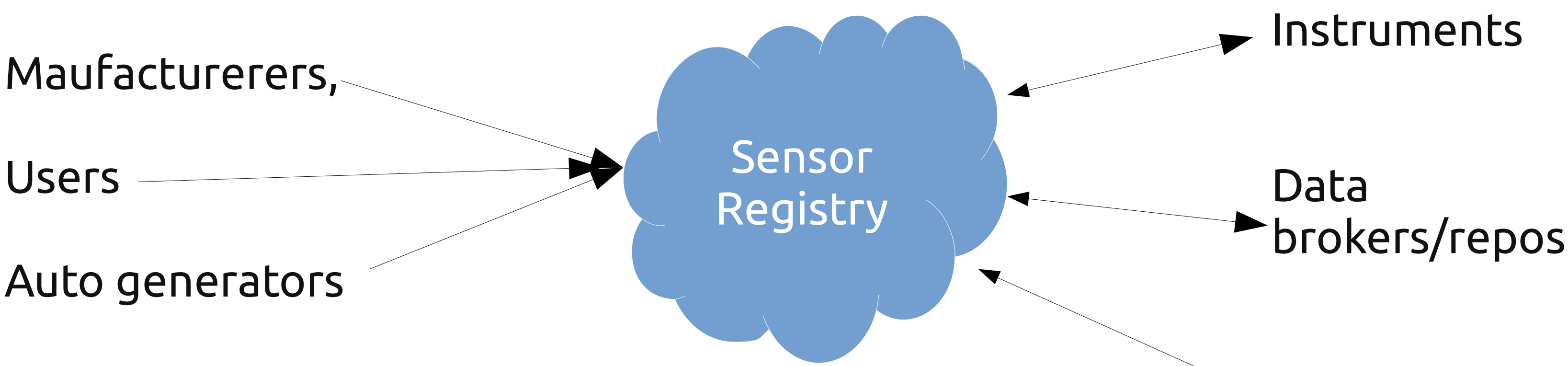
SSEDD

- ROS
  - Pub/Sub
  - Std Interfaces supported
  - Multi-sensor/actuator support
  - Very Mature
  - Feedback loop designed
  - ROS2 swarm potential
  - Standardising for drones in progress – Tully Foote, ELC 2016

ROS

SSEDD

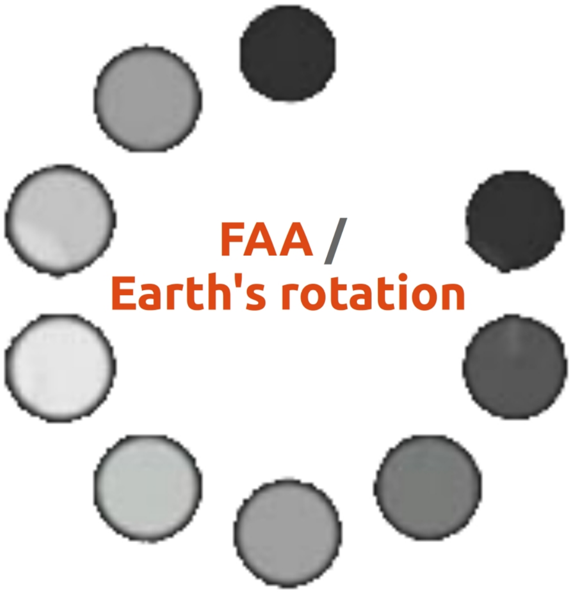
- X-DOMES: Queriable SensorML respository

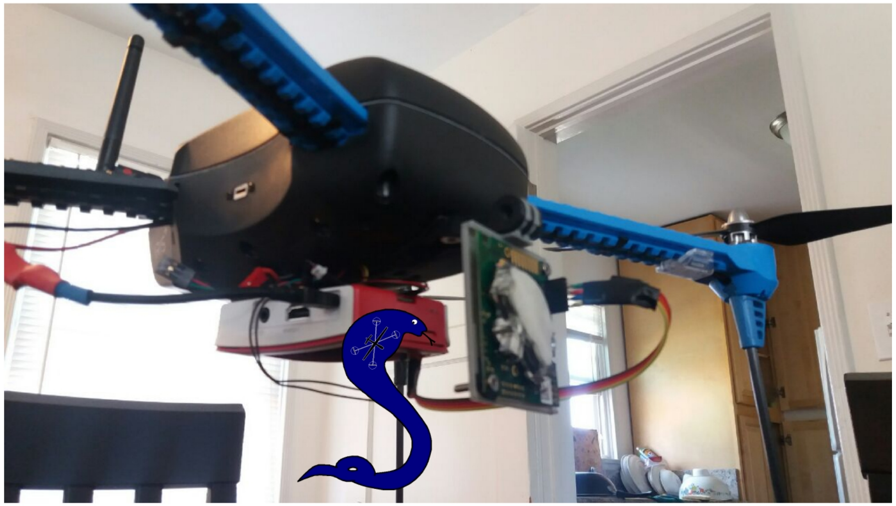


SSEDD

- MongoDB
  - Document store provides tolerance for dynamic data models, it being a
  - Direct search and retrieval
  - Guarantees of consistency and persistence,
  - NoSQL a better fit for complex multi-sensor geospatial data
  - Great geojson support
  - ARM support in progress…
- Schemas?

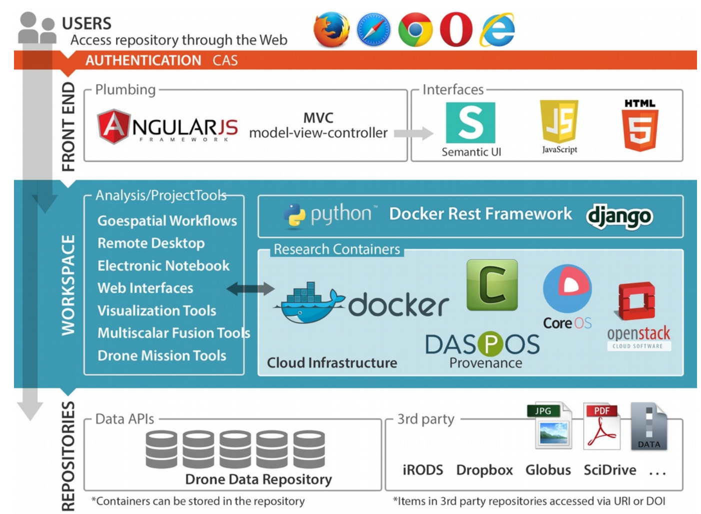
Test Results





Unsolved problems – the other bits

- Drones4Earth
  - Data sharing portal
  - Data Standards
    - Sensor registry
    - DB schemas
    - Data store formats
    - Metadata requirement standards
  - Data fusions tools
    - Satelite and UAS imagery
    - Low res and UAS high res LIDAR
    - Modelling – initialisation and validation
    - Multi-sensor composit visualisation



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Conclusions & Future plans

- Drones4Earth
  - Data Standards
  - Data sharing portal
  - Data processing tools
  - Data fusions tools
- SSEDD
  - Application snaps
  - Mission planner-
    CHORDS integration
- Community…

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